Survey of Northern Abalone, *Haliotis kamtschatkana,* Populations in Southeast Barkley Sound, British Columbia, July 2000 [Revised]

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V9T 6N7

2002

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2623

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Canadian Manuscript Report of Fisheries and Aquatic Sciences

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103-02754/

Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2623

2002

SURVEY OF NORTHERN ABALONE, *Haliotis kamtschatkana*, POPULATIONS IN SOUTHEAST BARKLEY SOUND, BRITISH COLUMBIA, JULY 2000

[REVISED]

by

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Cat. No. Fs 97-4/2623E ISSN 0706-6473

Correct citation for this publication:

Lucas, B.G., A. Campbell, D. Brouwer, S. Servant, and N. Webb. 2002. Survey of northern abalone, *Haliotis kamtschatkana*, populations in southeast Barkley Sound, British Columbia, July 2000. [Revised] Can. Manuscr. Rep. Fish. Aquat. Sci. 2623: 11 p.

ABSTRACT

Lucas, B.G., A. Campbell, D. Brouwer, S. Servant, and N. Webb. 2002. Survey of northern abalone, *Haliotis kamtschatkana*, populations in southeast Barkley Sound, British Columbia, July 2000. [Revised] Can. Manuscr. Rep. Fish. Aquat. Sci. 2623: 11 p.

A survey was conducted to provide an estimate of population numbers of emergent northern abalone in areas known to have abalone present in southeast Barkley Sound, British Columbia, during July 5 to 7, 2000. Abalone shell lengths (SL) ranged from 38 to 119 mm. The estimated mean density for abalone of all sizes in all areas combined was $0.10/m^2$, while the estimated mean density for abalone 90 – 110 mm SL in all areas was $0.04/m^2$. The estimated mean total population number (and 90% confidence interval) of emergent abalone for all sizes in all areas combined was 28,485 (16,553 – 40,416). The mean total population number (and 90% confidence interval) of emergent abalone for all areas combined in the 90 – 110 mm SL size range was estimated to be 12,558 (6,404 – 18,731). The highest concentration of abalone was found on the east side of Edward King Island, where the mean density for all sizes was $0.23/m^2$ and for abalone 90 – 110 mm SL was $0.11/m^2$. The estimated mean total population number (and 90% confidence interval) of emergent abalone for all sizes on the east side of Edward King Island was 20,624 (12,484 – 28,764), and for the 90 – 110 mm SL size range was 10,179 (3,634 – 16,724).

RÉSUMÉ

Lucas, B.G., A. Campbell, D. Brouwer, S. Servant, and N. Webb. 2002. Survey of northern abalone, *Haliotis kamtschatkana*, populations in southeast Barkley Sound, British Columbia, July 2000. [Revised] Can. Manuscr. Rep. Fish. Aquat. Sci. 2623: 11 p.

Un relevé a été effectué du 5 au 7 juillet 2000 pour estimer l'effectif des populations d'ormeaux nordiques émergents dans les secteurs du sud-est de la baie Barkley (Colombie-Britannique) où leur présence est connue. La longueur des ormeaux échantillonnés variaient de 38 à 119 mm. La densité moyenne des ormeaux de toutes tailles échantillonnés dans tous les secteurs a été estimée à $0,10/m^2$, et celle des ormeaux de longueur allant de 90 à 110 mm, à $0,04/m^2$. Pour l'ensemble des secteurs, l'effectif total moyen de la population d'ormeaux émergents de toutes tailles a été estimé à 28 485 (intervalle de confiance à 90 % : 16 553 – 40 416), et celui des ormeaux de longueur allant de 90 à 110 mm, à 12 558 (intervalle de confiance à 90 % : 6 404 – 18 731). La plus forte concentration d'ormeaux a été trouvée du côté est de l'île Edward King, où la densité moyenne était de $0,23/m^2$ pour les ormeaux de toutes tailles et de $0,11/m^2$ pour les animaux faisant de 90 à 110 mm de longueur. Dans ce secteur, l'effectif total moyen de la population d'ormeaux émergents de toutes tailles a été estimé à 20 624 (intervalle de confiance à 90 % : 12 484 – 28 764), et celui des ormeaux de longueur allant de 90 à 110 mm, à 10 179 (3 634 – 16 724).

INTRODUCTION

Northern abalone, *Haliotis kamtschatkana*, populations have declined in British Columbia (B.C.), despite complete closure of the fishery since 1990 for conservation purposes. Post-harvest surveys indicated that abalone densities were well below levels recommended to ensure sustainable populations (Breen 1986, Campbell et al. 1998). The future of *H. kamtschatkana* was sufficiently uncertain that in April 1999 this species was declared "Threatened" by COSEWIC (Committee on the Status of Endangered Wildlife in Canada).

Fisheries and Oceans Canada (DFO), in cooperation with coastal communities and other interested stakeholders, has begun an initiative to rehabilitate abalone stocks in B.C. Collection of broodstock will be required to implement the first step in this program, which is to develop aquaculture technology for this species.

To estimate the abundance of abalone stocks in areas of interest, an independent assessment using conventional survey methodology was required. Only emergent (visible) abalone were surveyed to provide a minimum estimate of mature adult population numbers; cryptic abalone were not surveyed in this census.

The objectives of this study were to determine densities, size frequencies, and population numbers of emergent northern abalone at four locations in Barkley Sound.

MATERIALS AND METHODS

FIELD METHODS

This survey was conducted during July 5 to 7, 2000, near Bamfield, B. C. (Figure 1). Four locations, Aguilar Point, Dixon Island, and east and west Edward King Island were selected, based on historical abundance of abalone and preliminary reconnaissance dives. The transect survey method (Cripps and Campbell 1998) was used for this study. Transects were randomly placed along the lengths of shoreline where populations were to be estimated. To avoid bias, these transect positions were determined in advance. The primary sampling unit was a "transect", made up of a cluster of secondary units, or quadrats. Each transect was 1 m wide and variable in length, depending on the slope of the substrate. Prior to entering the water, a lead line was laid perpendicular to shore from the boat in depths of approximately 12 m to 0 m from datum. The secondary sampling unit consisted of a 1 m x 1 m square quadrat that was placed along the transect, 1 m away, to avoid sampling areas disturbed by the lead line placement. Divers flipped the quadrat parallel to the transect line, from deep to shallow, and the number of "emergent" or "exposed" abalone, shell length (SL in mm) of each abalone, depth, substrate type, slope, and algal cover was recorded. Algal cover, sea urchins and starfish were removed from the quadrat to ensure all emergent abalone were detected. Boulders were not moved to search for cryptic abalone, since the majority of mature animals (i.e., ≥ 70 mm SL) are exposed (Campbell 1996). On transects where the slope of the substrate would have resulted in many quadrats, only a proportion (e.g., every other quadrat) were surveyed.

ANALYTICAL METHODS

All gauge depths were converted to depth (m) at chart datum. The survey results were analyzed according to Fisheries and Oceans Canada methodology (Campbell et al. 1999). To determine the size frequency distribution for a location, the number of abalone in each 5 mm SL size class was divided by the total number of abalone in each location.

The estimated mean density, $\bar{d}$ (number/m^2), of abalone was calculated as:

$$\bar{d} = \frac{\sum_t (d_t * L_t)}{\sum_t L_t} \qquad (1)$$

The standard error of the mean density, se_d, was calculated as:

$$se_d = \sqrt{1 - \frac{n}{T}} * \sqrt{\frac{\sum_t (d_t * L_t - \bar{d} * L_t)^2}{n * (n-1) * \bar{L}^2}} \qquad (2)$$

where n is the number of transects, d_t is the mean density (number/m^2) at transect t, L_t is the length of transect t (or area in square metres since each transect is one metre wide), $\bar{L} = \frac{\sum_t L_t}{n}$ is the mean transect length (or mean area in square metres), and T is the total possible number of transects that can be sampled in the surveyed area. The expression $\sqrt{1 - \frac{n}{T}}$ is approximately one, because the sample size n is small compared to T. This method accounts for the variable length of transects and for the variable proportion of quadrats surveyed along each transect.

To estimate the mean density for a specific size group (J), (e.g., 90 – 110 mm SL) the value d_t was substituted with densities ($P_{t,J}$) in equations 1 and 2. The mean density $P_{t,J}$ of abalone of size group J in transect t was calculated as:

$$P_{t,J} = \frac{\left(N_t * \frac{\sum_{i \in J} m_{t,i}}{M_t} \right)}{S_t} \qquad (3)$$

where J is a subset (e.g., 90 – 110 mm SL) of possible i values representing a range of shell lengths (SL_i), S_t is the number of quadrats surveyed for density estimates in transect t, N_t is the

number of abalone counted in transect t, $M_t = \sum_i m_{t,i}$ the total number of abalone measured for size in transect t, and $m_{t,i}$ is the number of abalone in size range J of transect t.

The approximate lower 90% confidence interval of the mean density (L90CI) was calculated as:

$$L90CI = \bar{d} - t_{\alpha/2} * se_d \quad (4)$$

where $t_{\alpha/2}$ is the critical t-distribution value at degrees of freedom of n-1.

The total number of abalone (X) in each location was calculated as:

$$X = \bar{d} * A \quad \text{or} \quad X = L90CI * A \quad (5)$$

where L90CI is the lower 90% confidence interval of the mean density for all sizes or for a particular size group of abalone, and A is the estimated area (m^2) of the surveyed location. The area of the location surveyed was calculated as the product of the mean transect length (since transects generally covered the breadth of suitable abalone habitat) and the length of the location as measured by the distance the between the two furthest shoreline points used when generating random transects.

RESULTS

Edward King Island and Aguilar Point were moderately exposed to wind and storms, with ground swells normal, while most of Dixon Island was well sheltered. The substrate consisted of bedrock, boulders, cobble and gravel, with some sand and shell (Table 1). The slope of the substrate (angle from horizontal) ranged from $2^o - 60^o$. The canopy was mostly *Nereocystis* along with some *Macrocystis* and *Pterygophora*. The predominant understory species was *Desmarestia*, followed by *Laminaria*. An unknown filamentous algae and articulated corraline algae were the most common turf algae, and encrusting corraline algae were abundant as bottom cover.

The depths surveyed ranged from -1.5 to 14.6 m from datum (Table 2). One hundred eighteen abalone were counted in quadrats along the 33 transects surveyed (Tables 2, 3). Aguilar Point had 11 abalone along 5 transects, where the mean transect length was 62 m. Dixon Island had 1 abalone along 6 transects, where the mean transect length was 59 m. East Edward King Island had 77 abalone along 11 transects, where the mean transect length was 60 m. West Edward King Island had 29 abalone along 11 transects, where the mean transect length was 93 m. Eleven transects surveyed (33%) had no emergent abalone. The maximum density of emergent abalone on a transect was 0.47 abalone/m^2.

Sizes of abalone surveyed ranged from 38 to 119 mm SL (Figure 2). The mean size of emergent abalone for all areas was 88 mm SL. Sizes of abalone found at Aquilar Point ranged from 63 to 119 mm SL. The one abalone found at Dixon Island measured 110 mm SL. East

Edward King Island abalone ranged from 38 to 114 mm SL. At West Edward King Island, the sizes of abalone found ranged from 62 to 110 mm SL. The mean size of emergent abalone was 98 mm SL at Aguilar Point, and 87 mm SL at both East and West Edward King Island.

Estimated mean total density of emergent abalone of all sizes in all areas combined was $0.10/m^2$ (Table 4). The mean population estimate was 28,485 emergent abalone in all the locations surveyed. The mean estimate of the number of abalone in the 90 – 110 mm SL size range for all areas was 12,558. The highest concentration of abalone was found on the east side of Edward King Island, where the mean density for all sizes was $0.23/m^2$ and for abalone 90 – 110 mm SL was $0.11/m^2$. The mean total population number of emergent abalone in the 90 – 110 mm SL size range was estimated for East Edward King Island to be 10,179.

DISCUSSION

The small mean size (< 100 mm SL), and the absence of large abalone (> 120 mm SL), in this survey suggest that some individuals are 'surf' abalone, whose growth is stunted by food or habitat limitations (Sloan and Breen 1988). The mean size is similar to the mean sizes (78 – 90 mm SL) measured at Edward King Island in 1984 (Emmett and Jamieson 1988), but smaller than the size range of abalone (51 – 146 mm SL) found in other areas of Barkley Sound in 1964 (Quayle 1971).

A conservative estimate of the total population numbers of emergent abalone of all sizes was provided by the lower 90% confidence interval (L90CI) for the mean, which was 125 abalone for Aguilar Point, 12,484 for East Edward King Island, and 0 for Dixon Island and West Edward King Island. The L90CI for mature emergent abalone 90 – 110 mm SL was 3,634 abalone for East Edward King Island, and 0 for Aguilar Point, Dixon Island, and West Edward King Island. The large uncertainty surrounding the estimated population means results, in part, from the small sample sizes. The lower confidence intervals provide more conservative estimates of population size than the mean estimates.

This survey provides no evidence of recovery of abalone populations since the province-wide closure in 1990. The total abalone densities found during this survey at East Edward King Island were lower than those found in the same area ($0.52/m^2$) in 1984 (Emmett and Johnstone 1985). All areas surveyed had low densities similar to other recent surveys in B.C. (Campbell et al. 1998; Lucas et al. 2002a, b, c). Since these low densities are well below those recommended to ensure sustainable populations (Breen 1986), the removal of any abalone from these areas must be considered with caution.

ACKNOWLEDGMENTS

We thank K. Fong and G. Parker for their assistance in organising this study; J. Harding, M. MacNab, and L. Verhegge for diving; and C. Hand for reviewing the manuscript.

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Table 1. Habitat summary for abalone transects surveyed in the Bamfield area, July 5 – 7, 2000. The most common substrates are listed (1 = first, 2 = second, 3 = third) where substrate code 1 = smooth bedrock, 2 = bedrock with crevices, 3 = boulders, 4 = cobble, 5 = gravel, 6 = pea gravel, 7 = sand, 8 = shell, and 9 = mud. The algae present are listed by growth characteristic for the most common (Sp 1) and second most common (Sp 2) species with the percentage of cover (%) for each, where AC = articulated coralline, AG = *Agarum*, AL = *Alaria*, CO = *Costaria*, DM = *Desmarestia*, EN = encrusting corraline, EG = *Egregia*, F = unknown foliose, GI = *Gigartina*, GR = sea grass, H = unknown hairy, LA = *Laminaria*, MA = *Macrocystis*, NT = *Nereocystis*, PL = *Pleurophycus*, PT = *Pterygophora*, R = unknown red, and UL = *Ulva*.

						Algae												Bottom Cover	
		Substrate			Slope	Canopy				Understory				Turf					
Transect	Date	1	2	3	degrees	Sp 1	%	Sp 2	%	Sp 1	%	Sp 2	%	Sp 1	%	Sp 2	%	Sp	%
Aguilar Point																			
AP-9	July 7	3	4	7	10	NT	5			NT	5	LA	5	H	15			EN	40
AP-11	July 7	8	7	4	30	NT	1			DM	1	MA	1	H	50			EN	40
AP-16	July 7	3	4	7	10	NT	5			LA	5	NT	5	H	15			EN	30
AP-30	July 7	3	4	7	20					LA	10	NT	10	H	10			EN	30
AP-39	July 7	3	4	8	45	NT	1			CO	1							EN	50
Dixon Island																			
DX-4	July 7	4	5	8	8									UL	40	GI	15	EN	10
DX-9	July 7	7	4	3	20									DM	1			EN	60
DX-17	July 7	2	7	3	50					DM	4	AL	1					EN	50
DX-26	July 7	3	4	7	10					EG	5	MA	5	GI	5	UL	5	EN	30
DX-30	July 7	2	7	4	45									H	2	UL	2	EN	50
DX-34	July 7	7	4	2	25									H	2			EN	95
East Edward King Island																			
EEK-10	July 6	3			10	NT	30	PT	10	PT	5	LA	5	AC	5			EN	90
EEK-31	July 6	2			20	NT	5			DM	10	NT	5					EN	60
EEK-35	July 6	2	4	5	10	NT	5			NT	5	DM	5	F	5			EN	50
EEK-47	July 6	3	4	8	20	NT	8			AL	1	CO	1					EN	70
EEK-52	July 6	1	2		20	NT	1			LA	1			AC	3			EN	90
EEK-57	July 6	1	2	3	30	NT	5			NT	5	LA	5	AC	5			EN	70
EEK-76	July 6	2	4	5	20					DM	5			F	5			EN	70
EEK-82	July 6	1	2	3	30	NT	1			DM	5	LA	1	AC	2			EN	80
EEK-85	July 6	1	3		10					LA	10	NT	5					EN	60
EEK-86	July 6	2	3	4	15					LA	10	DM	5					EN	60
EEK-94	July 6	3	4	2	60	NT	1			LA	1							EN	80
West Edward King Island																			
WEK-11	July 5	3	4	6	15	NT	20			LA	20	NT	20	F	5			EN	40
WEK-25	July 5	1	2	3	45													EN	60
WEK-36	July 5	3	4	8	20	NT	2			DM	25	LA	1					EN	75
WEK-42	July 5	3	4	1	2	MA	5	NT	5	NT	5			AC	5	R	5	EN	90
WEK-43	July 5	4	3	1	3	MA	1	PT	1	DM	2			R	2			EN	80
WEK-45	July 5	1	2	7	5	NT	1			DM	5	EG	1	AC	5			EN	50
WEK-48	July 5	1	3	4	60	NT	30	MA	30	LA	10	AL	5	AC	2			EN	85
WEK-59	July 5	1	2	8	20	NT	20			DM	10	LA	1					EN	90
WEK-69	July 5	3	2	7	10	NT	1			NT	1			R	1			EN	80
WEK-89	July 5	4	3		3	NT	5			DM	5			AC	10				
WEK-97	July 5	1	3	4	50	NT	2			CO	2	NT	1	AC	5			EN	90

Table 2. Dive summary for abalone transects surveyed in the Bamfield area, July 5 – 7, 2000.

		Time			Depth (m)		Number of	Transect	Number of Abalone		Density (#/m2)	
Transect	Date	Start	Finish	Bottom	Min	Max	Quadrats	Length (m)	all sizes	90-110mm	all sizes	90-110mm
Aguilar Point												
AP-9	July 7	10:49	11:07	0:18	0.82	11.43	27	53	5	0	0.19	0.00
AP-11	July 7	10:05	10:30	0:25	0.67	10.30	29	57	3	3	0.10	0.10
AP-16	July 7	10:04	10:24	0:20	0.30	11.46	43	85	2	1	0.05	0.02
AP-30	July 7	9:15	9:40	0:25	-0.91	9.54	30	59	1	0	0.03	0.00
AP-39	July 7	9:20	9:45	0:25	0.06	10.21	28	55	0	0	0.00	0.00
Dixon Island												
DX-4	July 7	13:17	13:39	0:22	-0.46	10.67	18	101	0	0	0.00	0.00
DX-9	July 7	13:44	14:13	0:29	-0.12	10.18	34	67	0	0	0.00	0.00
DX-17	July 7	12:50	13:20	0:30	-0.34	11.43	31	61	0	0	0.00	0.00
DX-26	July 7	12:24	12:49	0:25	-0.15	10.00	31	61	1	0	0.03	0.00
DX-30	July 7	12:20	12:36	0:16	0.52	11.52	15	29	0	0	0.00	0.00
DX-34	July 7	10:55	11:16	0:21	0.24	11.16	18	35	0	0	0.00	0.00
East Edward King Island												
EEK-10	July 6	9:42	10:42	1:00	1.16	10.06	42	83	4	1	0.10	0.02
EEK-31	July 6	9:45	10:04	0:19	0.73	12.53	17	33	2	1	0.12	0.06
EEK-35	July 6	10:25	11:14	0:49	1.16	11.49	39	77	13	7	0.33	0.18
EEK-47	July 6	11:20	12:05	0:45	0.98	14.57	46	91	3	2	0.07	0.04
EEK-52	July 6	14:40	15:05	0:25	0.52	9.91	16	31	5	3	0.31	0.19
EEK-57	July 6	11:40	11:56	0:16	0.09	11.46	15	29	6	3	0.40	0.20
EEK-76	July 6	12:29	12:57	0:28	1.49	11.49	40	79	3	1	0.08	0.03
EEK-82	July 6	12:35	13:05	0:30	0.52	11.13	24	47	6	1	0.25	0.04
EEK-85	July 6	13:40	14:12	0:32	-0.76	9.33	38	75	9	6	0.24	0.16
EEK-86	July 6	14:25	15:15	0:50	-1.13	9.75	38	75	18	9	0.47	0.24
EEK-94	July 6	14:00	14:20	0:20	-0.55	11.55	20	39	8	4	0.40	0.20
West Edward King Island												
WEK-11	July 5	10:00	10:55	0:55	2.23	11.16	37	73	17	4	0.46	0.11
WEK-25	July 5	9:50	10:10	0:20	2.93	12.98	36	36	3	0	0.08	0.00
WEK-36	July 5	10:25	11:05	0:40	2.19	9.94	65	129	6	6	0.09	0.09
WEK-42	July 5	11:40	12:25	0:45	0.58	11.37	56	166	0	0	0.00	0.00
WEK-43	July 5	12:55	13:35	0:40	-0.15	9.39	47	139	0	0	0.00	0.00
WEK-45	July 5	13:03	13:45	0:42	-0.34	2.87	24	47	0	0	0.00	0.00
WEK-48	July 5	13:55	14:05	0:10	0.67	9.30	11	21	0	0	0.00	0.00
WEK-59	July 5	14:35	15:15	0:40	4.08	8.56	34	67	1	0	0.03	0.00
WEK-69	July 5	15:07	15:46	0:39	2.53	8.78	40	118	0	0	0.00	0.00
WEK-89	July 5	16:15	17:08	0:53	-1.52	7.32	38	185	1	0	0.03	0.00
WEK-97	July 5	16:15	16:30	0:15	0.88	9.14	19	37	1	0	0.05	0.00

Table 3. Summary statistics and area surveyed for transect survey of emergent abalone from the Bamfield area, July 5 – 7, 2000. Values in brackets are standard errors.

Details per transect	Aguilar Point	Dixon Island	E Edward King I	W Edward King I	All areas
Number of transects	5	6	11	11	33
Number of abalone	11	1	77	29	118
Mean transect length (m)	61.80 (5.89)	59.00 (10.51)	59.91 (7.22)	92.55 (17.21)	70.91 (6.89)
Mean number of quadrats	31.40 (2.94)	24.50 (3.41)	30.45 (3.61)	31.70 (2.18)	31.70 (2.18)
Mean depth (m)	6.14 (0.25)	4.86 (0.29)	6.08 (0.17)	5.36 (0.15)	5.64 (0.10)
Mean minutes/transect	22.60 (1.50)	23.83 (2.15)	34.00 (4.43)	36.27 (4.47)	31.18 (2.30)
Mean minutes/quadrat	0.74 (0.08)	1.01 (0.07)	1.14 (0.08)	1.03 (0.11)	1.02 (0.05)
Shoreline distance (m)	250	730	1500	1500	3980
Area surveyed (m^2)	15,450	43,070	89,865	138,825	287,210

Table 4. Mean densities (number/m^2) and populations estimates of emergent abalone from the Bamfield area, July 5 – 7, 2000. Values in brackets are 90% confidence intervals.

Details per location	Aguilar Point	Dixon Island	E. Edward King Is.	W. Edward King Is.	All areas
Mean density all sizes	0.07 (0.01 - 0.13)	0.01 (-0.01 - 0.02)	0.23 (0.14 - 0.32)	0.06 (-0.02 - 0.13)	0.10 (0.06 - 0.14)
Mean density 90 - 110 mm SL	0.03 (-0.01 - 0.07)	0.00 (-0.02 - 0.02)	0.11 (0.04 - 0.19)	0.02 (-0.01 - 0.05)	0.04 (0.02 - 0.07)
Total population all sizes	1,082 (125 - 2,038)	239 (-247 - 726)	20,624 (12,484 - 28,764)	7,085 (-2,415 - 18,025)	28,485 (16,553 - 40,416)
Population 90 - 110 mm SL	394 (-220 - 1,008)	0 (-813 - 813)	10,179 (3,634 - 16,724)	2,700 (-1,274 - 6,674)	12,558 (6,404 - 18,731)

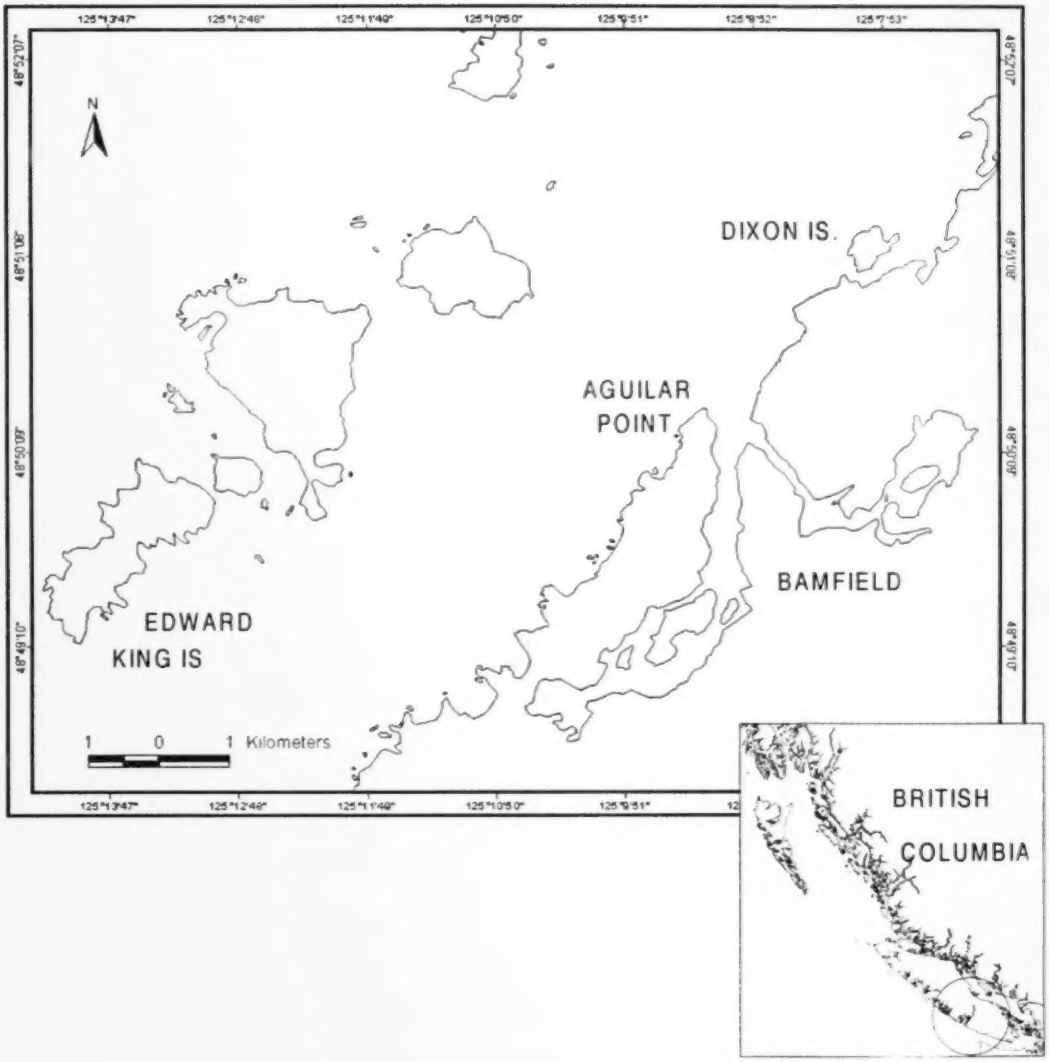

Figure 1. Abalone survey locations in the Bamfield area, July 5 – 7, 2000. The inset shows the detailed area of Barkley Sound, Vancouver Island, British Columbia.

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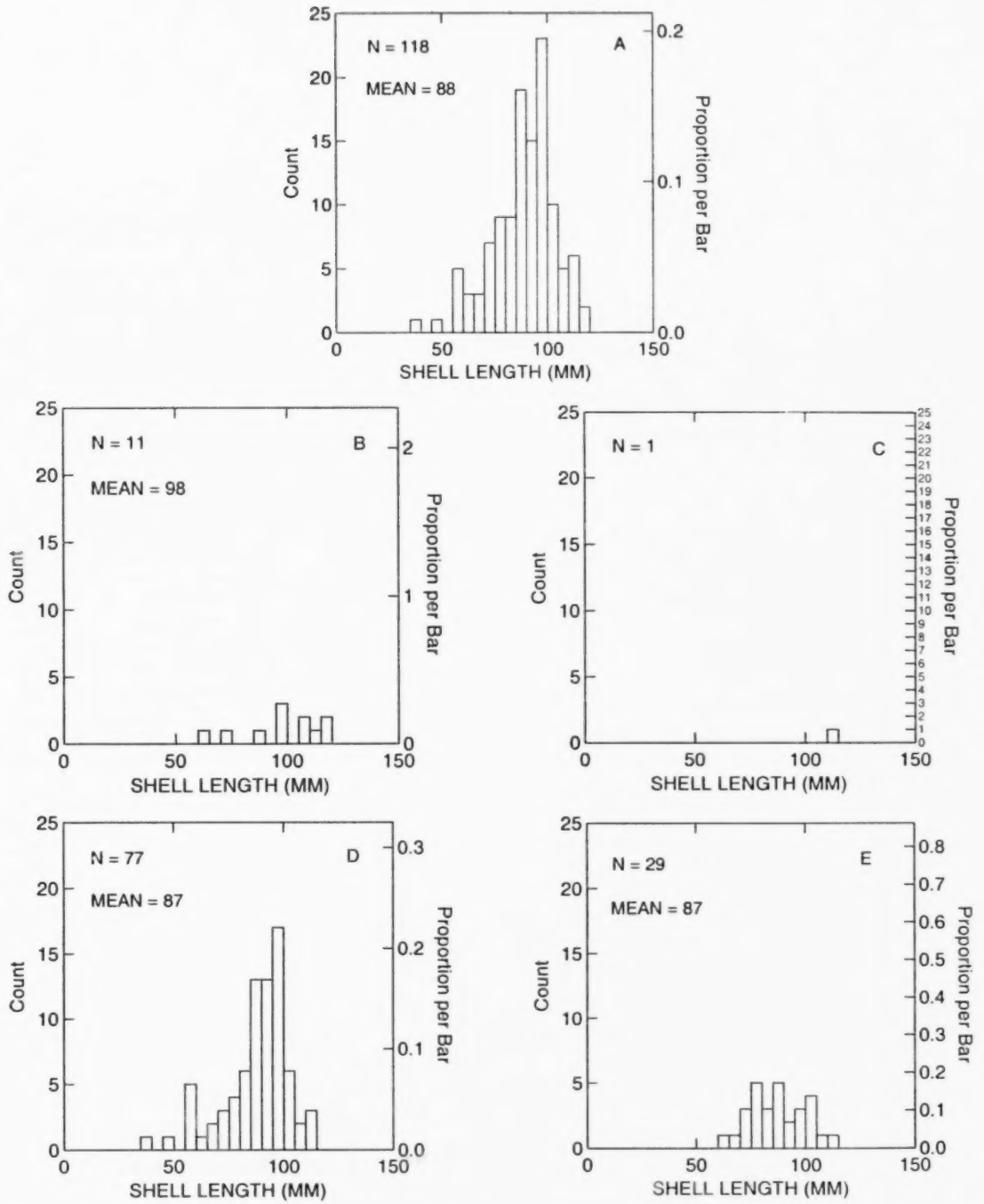

Figure 2. Size frequencies of emergent abalone found in quadrats during dive surveys in the Bamfield area, July 5 – 7, 2000, are shown for A) all areas combined, B) Aguilar Point, C) Dixon Island, D) East Edward King Island, and F) West Edward King Island. Number of abalone (N) and mean shell length in mm are shown.